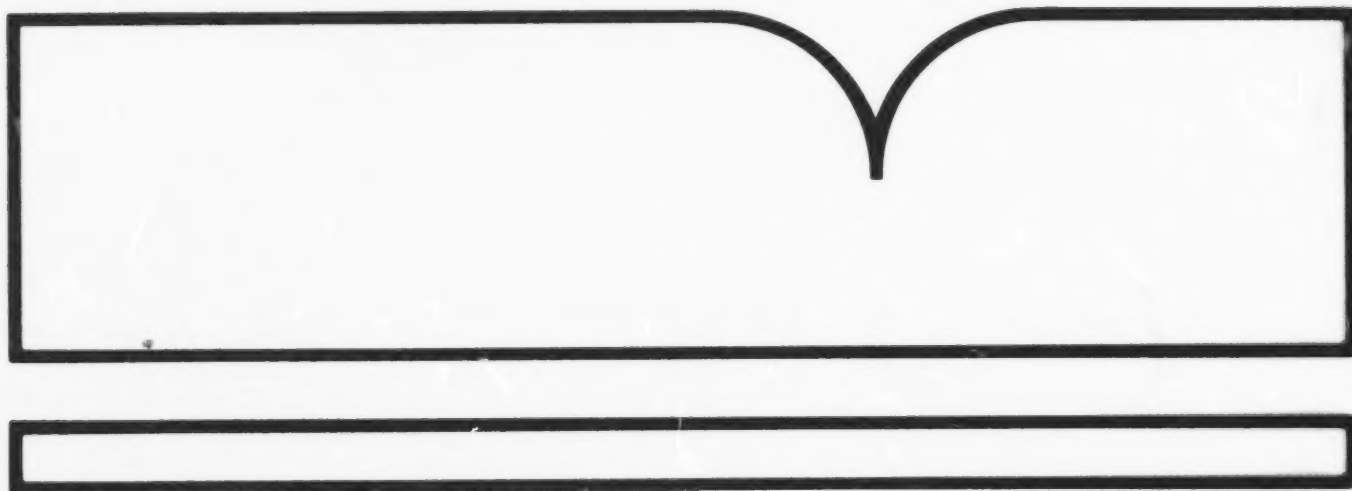


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Toxicity Bioassay and Eluate Heavy Metals Analysis
Results of the Bench Scale Stabilization Study of
Soils from the United Chrome Superfund NPL (National
Priority List) Site Corvallis, Oregon

(U.S.) Corvallis Environmental Research Lab., OR

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CORVALLIS, OREGON

ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
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SUMMARY

This report describes tests performed at Environmental Research Laboratory, Corvallis (ERL-C) to assist United States Environmental Protection Agency (EPA) Region 10 in evaluating a soil stabilization procedure proposed to remediate the National Priority List site United Chrome, Corvallis, Oregon. A series of toxicity bioassays and chemical analyses were performed on site soil and reference soil and stabilized site and stabilized reference soil. The conclusions drawn from the testing are:

- 1) the stabilization process did not eliminate site soil toxicity to the species tested;
- 2) the stabilization process did not bind chromium in a manner that prevented elution of the metal; and
- 3) the stabilization mixture of record appears to have some innate toxic properties.

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INTRODUCTION

United Chrome Products, Inc. (United Chrome) was an active hard-chrome plating facility in Corvallis, Oregon from 1957 through 1977. Subsequently, the site was placed on the National Priority List (NPL) and the Superfund (CERCLA) process was initiated. While an active chrome-plating operation, United Chrome discharged chrome-plating wastes into a dry-well. The discharge which contained substantial quantities of chromium, constituted a potential human health hazard (Ecology and Environment, Inc. 1983).

In 1985, Region 10 completed a technology review that identified soil stabilization, a solidification process, as a promising remedial technique. As part of that review, a bench scale study involving soil from a National Priorities List site (Western Processing, Tacoma, Washington) was completed in 1985/86 (Barich, et al., 1987; Greene, et al., 1988a). In that EPA review, three commercial soil stabilization vendors submitted stabilized soil cylinders that represented the best achievable performance with their technologies. Performance was evaluated by chemical analysis of Toxicity Characteristic Leaching Procedure (TCLP; Friedman, 1985) eluates prepared by sodium acetate elution of soils before and after stabilization. One stabilization method reduced total chromium concentration in stabilized Western Processing soil eluates by 30%, while reductions in Zn, Cd, Ni, Cu, Ba, and Pb concentrations ranged from 85 to 100%. The soil stabilization trials with Western Processing suggested that at bench scale, soil stabilization could substantially reduce heavy metal concentrations as measured by the Toxicity Characteristic Leaching Procedure (TCLP). Toxicity tests performed on sample eluates, however, determined that none of the stabilization techniques reduced toxicity on the Western Processing site. Soil eluates prepared with deionized water indicated that stabilization appeared to increase metals released during elution, and eluate toxicity was subsequently increased (Greene et al, 1988a).

For the United Chrome site, Region 10 also needed to evaluate soil stabilization as performed by representative technologies to determine the best available technology that would effectively reduce the leaching of toxic metals from United Chrome contaminated soils. In support of EPA Region 10 and their United Chrome studies ERL-C staff performed toxicity bioassays and selected chemical analyses. Direct toxicity tests (ie. using soil as the medium) and indirect toxicity tests (ie. using eluates obtained from the samples) were performed. This report presents test results for toxicity bioassays and chemical analyses for heavy metals.

METHODS

MATERIALS TESTED. ERL-C received the following samples to be tested:

- 1) soil collected from the dry well on-site (#14)
- 2) soil collected from an uncontaminated reference site located south of the dry well
- 3) subsamples of the two soils samples that were "stabilized" with a proprietary Mix of Record (MOR)

TESTING RATIONALE. The bioassessment protocols used in evaluating the short-term toxicity associated with site-samples from the United Chrome site comprise a multi-media battery of single-species toxicity tests. These terrestrial and aquatic toxicity tests provide a comparative toxicity data base that contributes to site characterization and the hazard evaluation process (Athey, et al. 1987). Site-samples may be tested directly (e.g., as soil) or indirectly [e.g., aqueous and solvent extracts (=eluates)]. Eluates may then be evaluated to determine the potential for chemical constituent mobility from the complex chemical mixtures characteristic of hazardous waste site soil samples.

Site-specific considerations influence the toxicity tests which are appropriate to any given waste site evaluation, and support the application of the multi-media, single-species test battery approach toward bioassessment (see also, Thomas, et al. 1986, Miller, et al. 1985). The bioassessment protocol followed at ERL-C includes tests that evaluate toxicity and the biological responses of representative terrestrial organisms (macroinvertebrates represented by the earthworm, and various plant species such as lettuce and radish), as well as aquatic organisms (macroinvertebrates, Daphnia magna and algae, Selenastrum capricornutum).

SOIL SAMPLE PREPARATIONS. Toxicity bioassays performed directly on site-soils included the earthworm and seed germination tests. Sample soil was screened through a 1/4" soil sieve prior to testing. The soil sample was adjusted for pH (6.2 to 6.4) and water content. Soil samples were then mixed with artificial soil to derive test concentrations in the logarithmic exposure series for either the earthworm or seed germination tests. Artificial soil was used as the negative control medium. The endpoints (mortality of earthworm or inhibition of seed germination) evaluated at the end of the bioassay were used to generate toxicity estimates expressed as LC₅₀ (concentration of site soil that yielded 50% mortality or inhibition of seed germination). Statistical analyses and determination of toxicity estimates were calculated using techniques outlined in Stephan (1977), Hamilton, et al. (1977), and

Stephan and Rogers (1985). Refer to Greene, et al. (1989) for detailed bioassay protocols which were used in these direct tests.

AQUEOUS ELUATE PREPARATIONS FROM SITE SOILS. To evaluate the mobility of chemical constituents characteristic of hazardous waste site complex mixtures, eluates were prepared from untreated site-soils. Briefly, site-samples were mixed with four volumes deionized water per gram dry weight site-soil. The slurry was then mixed end-over-end at 30 rpm at 20 +/- 2 C for 48 hours in the dark. After mixing, the resulting eluate was centrifuged and filtered through a 0.45 um cellulose acetate or glass fiber filter. Eluate preparation incorporated original sample moisture content into its preparation and hence, a constant solute/solvent ratio was assured during the extraction of any site-sample. The filtered eluates were subsequently evaluated with the root elongation test, daphnid or algal bioassays. Exposures in these aquatic toxicity bioassays consist of eluate mixed with dilution water in a logarithmic series of concentrations capable of yielding the desired toxicity estimates (LC_{50} or EC_{50}). Estimates of biological response were generally calculated as short-term toxicity measurements (either LC_{50} s or EC_{50} s) according to statistical procedures outlined in Stephan (1977), Hamilton, et al. (1977), and Stephan and Rogers (1985). Greene, et al. (1989) should be consulted for complete details on sample preparation and testing.

ELUTION WITH SODIUM ACETATE (MODIFIED TCLP PROCEDURE). Eluates were also prepared following a modified TCLP procedure outlined for the US EPA Organic Toxicity Characteristic Workgroup (Friedman 1985). A 0.1N pH 5 sodium acetate buffer, used for eluting soils, was prepared by adding 50 ml of 5N sodium acetate buffer solution to a final volume of 2 liters deionized water. Sodium acetate eluates were prepared by mixing four ml sodium acetate buffer solution per gram dry weight of site soil. Preparation of the eluate incorporated the original sample moisture content. The pH of the slurry was not adjusted. Elution occurred at the pH that resulted from the sodium acetate/soil mixture. The slurry was mixed end-over-end at 30 rpm, in the dark, for 48 hours at 20 +/- 2 C. At the conclusion of mixing the eluate was centrifuged and filtered through a 0.45 um cellulose acetate or glass fiber filter. Toxicity tests were subsequently completed on pH-adjusted eluates using one of the aquatic test systems.

CHEMISTRY SUPPORT. Inductively coupled plasma, atomic emission spectroscopy (ICPAES) was completed on site-soil eluates. Standard US EPA methodologies were followed in sample preparation and analysis. Routine water chemistries [hardness, salinity, conductivity and pH] were determined for each eluate. Sample pH was measured prior to toxicity bioassays. Those having pH less than 6.0 were adjusted to pH 6.2 to 6.4 prior to performing the bioassay.

Hardness, salinity, and conductivity were routinely measured, and calculated values based upon ICPAES results verified those measurements which are reported with ICPAES results herein. ERL-C did not perform chemical analysis on the parent soils.

TEST ORGANISMS AND PROCEDURES. Toxicity tests used in this study were both direct and indirect tests. Direct tests using site or reference soils were the 14-day earthworm test and the Neubauer seed germination bioassay (120-hour); indirect tests performed on eluates included the algal bioassay (short-term toxicity test, S. capricornutum 96-hour static exposure); the 48-hour D. magna static acute bioassay; and the root elongation short-term test (120-hour exposure). These direct and indirect tests are summarized in Greene, et al. (1989). Microbial tests [Microtox and Toxi-Chromotest, and SOS-chromotest with and without S9] were also performed on sample eluates and are briefly summarized below.

Microtox[®] (30-minute). Microtox[®] measures bioluminescence in Photobacterium phosphoreum, and the tests were performed following the procedure detailed in the Beckman Microtox[®] Operating Manual (1982). Tests were performed in duplicate using four eluate concentrations per test; tests were incubated for 30 minutes. Generally, toxicity in Microtox[®] is reflected by a diminished luminescence in exposed cultures. The highest eluate concentration tested was 45 percent, and an EC₅₀, defined as the test concentration associated with a 50% reduction in bioluminescence relative to control, was estimated using simple linear regression analysis.

Toxi-Chromotest[®] is a short-term microbial toxicity test system using an Escherichia coli bacterial strain which possesses altered cell membrane permeabilities. Biological effects of toxicants are assessed by measuring the activity of inducible B-galactosidase. The assay is based on the ability of toxic substances to inhibit de novo synthesis of an inducible enzyme, B-galactosidase, in a highly permeable mutant of E. coli. The sensitivity of the test is enhanced by exposing the bacteria to stressing conditions, then test cultures are rehydrated in a cocktail containing a specific inducer of B-galactosidase and essential factors required for the recovery of the bacteria from their stressed condition. Toxicants interfere with the recovery process and hence, the synthesis of the enzyme. The activity of the induced enzyme is detected by hydrolysis of a chromogenic substrate which is measured using a microplate reader at an absorbance of 405 nm (Organics 1985). For the United Chrome toxicity tests, Toxi-Chromotest[®] was completed in 96-well microtiter plates following 1.5 to 2 hours incubation. Assays were performed in duplicate using seven eluate concentrations per test;

the highest eluate concentration tested was 33.3 percent. Endpoint calculations were based on the percent inhibition of chromogen hydrolysis compared to controls. An EC_{50} , defined as the test concentration associated with a 50 percent reduction in enzyme activity relative to control, was calculated using simple linear regression analysis.

The SOS-Chromotest differs from Toxi-chromotest primarily in the mode of expression of the B-galactosidase activity; SOS-Chromotest uses the altered E. coli strain with the B-galactosidase gene linked to the SOS operator gene. Exposure to a genotoxic substance and the activation of the SOS system results in the induction of the B-galactosidase gene leading to production of the enzyme. SOS-Chromotest may also be performed using S-9 supplemented systems to evaluate the potential for metabolic activation in test samples. The extent of enzyme expression was quantified spectrophotometrically as the endpoint as in the Toxi-chromotest (Organics 1985).

STATISTICS. Statistical analyses and determination of toxicity estimates were calculated using techniques outlined in Stephan (1977), Hamilton, et al. (1977), and Stephan and Rogers (1985). Refer to Greene, et al. (1989) for detailed test protocols.

QUALITY CONTROL AND QUALITY ASSURANCE. The Quality Assurance Plan (QAP) of the ERL-C Plant Toxicology & Hazardous Waste Team details requirements pertinent to both sample receipt, processing, chemical and biological testing. Complete sample histories and processing records are available from the ERL-C project officer.

RESULTS AND DISCUSSION

This bench scale study of soil stabilization consisted of two samples: a reference soil collected approximately 100 yards southeast of the site; and, soil collected from the highly contaminated dry well (subsample #14). Although each sample was analyzed in a variety of tests (chemical and several toxicity bioassays) caution must be exercised in developing inferences from the results since the samples were not replicated. In the absence of statistical discrimination the results discussed below should be viewed as contributing to "a weight of evidence" evaluation.

Chemical analyses (Table 1) were performed on each of the non-stabilized and stabilized soils. Total chromium concentration was high in the deionized water eluate prepared from the non-stabilized dry well soil. The eluate contained high concentrations for total Cr, Zn, Ni, As, B, and Co. The total chromium concentration measured in the stabilized dry well soil eluate was over 75 percent

less than the total chromium measured in the eluate prepared from the non-stabilized dry well soil (Table 1). Heavy metal constituents, other than chromium, in the deionized water eluates prepared from the non-stabilized and stabilized dry well soil showed that Zn, Cr, Co, As, and Ni concentrations were reduced by approximately 95, 75, 60, 50, and 20 percent, respectively. On the other hand, measured concentrations for Mo, Cu, Pb, and hardness increased markedly.

Though toxicity differences between trivalent and hexavalent chromium have been noted (US EPA 1980), the comparative toxicity screening battery reported here (Table 2) makes no distinction between these chemical species, but rather assesses the composite toxicity of the chemical mixtures that are characteristic of the United Chrome samples.

REFERENCE SOIL--NON-STABILIZED. The non-stabilized reference soil was non-toxic for both direct and indirect bioassays on terrestrial and aquatic organisms (Table 2). Chemical analysis for metals (Table 1) support this assessment.

REFERENCE SOIL--STABILIZED. Bioassays performed in deionized water eluates of the stabilized reference soil, however, exhibited toxicity as indicated by inhibition of algal growth and root elongation. High toxicity was also measured in the lettuce seed germination bioassay that was performed in the parent stabilized reference soil. The lettuce root elongation test indicated low toxicity and did not permit calculation of an EC_{50} . Root elongation, however, was inhibited by about 32% in the full-strength eluate material. The algal assay demonstrated moderately high toxicity with an EC_{50} of 30.3% eluate. Unknown constituents in the stabilization formula (MOR) caused the soil eluate to become toxic to plants. The results from heavy metals analysis (Table 1) provided little clear information to the cause of phytotoxicity. Copper and nickel concentrations increased substantially over those measured in the non-stabilized soil eluate, but the increased eluate hardness may be a contributing factor. *D. magna* and earthworms (*Eisenia andrei*) were both unaffected by these constituents, as suggested by their lack of response when exposed to the deionized water eluates or the parent soil, respectively.

DRY WELL SOIL--NON-STABILIZED. Bioassays reported high toxicity in all test systems. The data indicate that chromium was the constituent most likely responsible for the toxicity measured in the deionized water eluate prepared from the non-stabilized dry well soil. Additional bioassay results in this and previous studies support this conclusion.

Table 1. Eluate chemical values of reference and Dry Well #14 soils.
Values for element concentrations and hardness are expressed in mg/l.

	Ca	Mg	Na	K	HARDNESS	pH	
						INIT.	FIN.
Background (Reference)							
Non-Stabilized							
Aqueous Eluate	1.5	0.8	1.9	0.4	7.1	6.3	6.5
TCLP Eluate	85.0	33.7	20323.0	7.9	351.0	4.9	6.2
Stabilized							
Aqueous Eluate	339.9	0.1	75.5	49.1	848.9	11.9	8.6
Dry Well # 14							
Non-Stabilized							
Aqueous Eluate #1	10.2	15.0	341.9	559.6	87.3	4.3	4.3
Aqueous Eluate #2	5.3	12.9	320.2	709.7	66.5	4.4	6.3
TCLP Eluate	10.7	11.4	20323.0	660.1	73.7	4.7	6.2
Stabilized							
Aqueous Eluate	104.4	0.0	116.9	1516.7	260.7	11.9	7.4
	P	Al	Fe	Mn	Zn	Cu	Cd
Background (Reference)							
Non-Stabilized							
Aqueous Eluate	0.055	2.457	1.847	0.044	0.017	0.000	0.000
TCLP Eluate	0.134	0.251	0.067	1.293	0.230	0.003	0.005
Stabilized							
Aqueous Eluate	0.037	0.086	0.034	0.000	0.000	0.119	0.000
Dry Well #14							
Non-Stabilized							
Aqueous Eluate #1	0.000	0.782	0.132	0.783	0.156	0.000	0.000
Aqueous Eluate #2	0.177	0.670	0.247	0.899	0.047	0.012	0.007
TCLP Eluate	0.156	0.098	6.348	0.888	0.608	0.591	0.011
Stabilized							
Aqueous Eluate	0.533	0.188	0.116	0.000	0.006	0.555	0.000
	Cr	Ni	As	Pb	B	Co	Mo
Background (Reference)							
Non-Stabilized							
Aqueous Eluate	0.000	0.000	0.000	0.000	0.000	0.025	0.000
TCLP Eluate	0.006	0.026	0.022	0.035	0.166	0.031	0.003
Stabilized							
Aqueous Eluate	0.000	0.124	0.000	0.000	0.000	0.000	0.020
Dry Well #14							
Non-Stabilized							
Aqueous Eluate #1	87.750	0.256	0.094	0.000	0.430	0.084	0.000
Aqueous Eluate #2	126.824	0.215	0.113	0.076	0.246	0.055	0.014
TCLP Eluate	104.400	0.306	0.137	0.054	0.159	0.083	0.013
Stabilized							
Aqueous Eluate	20.873	0.209	0.047	0.192	0.000	0.032	0.653

Table 2. Toxicity values (EC50 or LC50) expressed as the percentage of sample. [Dry well #14 aqueous eluate was prepared twice and several toxicity assays were repeated.]

	Algae	Daphnia	Lettuce Root Elongation
Background (Reference)			
Non-Stabilized Aqueous Eluate	NE	NE	NE
TCLP Eluate	0.5 (0.2-1.6)	44.5 (42.1-47.0)	6.7 (0.0-100.0)
Stabilized Aqueous Eluate	30.3 (16.6-58.2)	NE	-31.9
DRY WELL #14			
Non-Stabilized Aqueous Eluate (Run #1)	0.2 (0.1-1.0)	IS	4.6 (3.5-60.1)
(Run #2)	0.1 (<0.1-0.2)	0.6 (0.5-0.7)	NR
TCLP Eluate	0.2 (<.2->.2)	0.8 (0.7-0.9)	2.6 (1.0-9.8)
Stabilized Aqueous Eluate	3.0 (1.6-5.8)	1.7 (1.3-2.2)	4.4 (0.0-100.0)

NE = Tested material showed no negative biological effect.
 NA = Not applicable/material not appropriate for the test.
 IS = Insufficient sample to perform the test.
 NR = Performance of this test not required or requested.

Table 2. (Cont.)

	Toxi- Chromo Test	30 Minute Microtox	GENOTOXICITY SOS Chromotest	
			-S9	+S9
Background (Reference)				
Non-Stabilized				
Aqueous Eluate	NE	NE	NE	NE
TCLP	2.2 (3<0.1-100.0)	32.8	NE	NE
Stabilized				
Aqueous Eluate	NE	NR	NE	NE
DRY WELL #14				
Non-Stabilized				
Aqueous Eluate	0.7	97.5	1.7	3.3
(Run #1)	(<0.1-15.9)		(0.2-4.7)	(1.0-11.0)
(Run #2)	1.9	77.7	NE	3.5
	(0.5-7.9)			(1.4- 8.8)
TCLP Eluate	<0.1	18.8	2.8	3.2
		(17.9-21.6)	(1.0-4.6)	(0.8-12.0)
Stabilized				
Aqueous Eluate	6.6	NR	NE	NE
	(2.8-12.6)			

NE = Tested material showed no negative biological effect.

NA = Not applicable/material not appropriate for the test.

IS = Insufficient sample to perform the test.

NR = Performance of this test not required or requested.

Table 2. (Cont.)

	Earthworm	Seed Germination
Background (Reference)		
Non-Stabilized		
Aqueous Eluate	NE	NE
TCLP	NA	NA
Stabilized		
Aqueous Eluate	IS	<5.0
DRY WELL #14		
Non-Stabilized		
Aqueous Eluate	16.3	0.5
(Run #1)	(15.9-16.7)	(0.4-0.6)
(Run #2)	NR	NR
TCLP Eluate	NA	NA
Stabilized		
Aqueous Eluate	IS	<5.0

NE = Tested material showed no negative biological effect
 NA = Not applicable/material not appropriate for the test
 IS = Insufficient sample to perform the test.
 NR = Performance of this test not required or requested.

DRY WELL SOIL STABILIZED. The deionized water eluate prepared from the stabilized dry well soil was found to be highly alkaline (pH 11.9), and exceeded the tolerance limits of S. capricornutum, D. magna, and the lettuce seed (L. sativa) (Peterson et al., 1987). Consequently, test solutions were adjusted to pH 7.4 prior to completing toxicity tests.

Both the non-stabilized and stabilized dry well soil eluates were highly toxic to D. magna. While the test results suggested that the eluate prepared from the stabilized dry well soil was somewhat less toxic than the eluate prepared from the non-stabilized soil, the stabilization process did not eliminate toxicity from the treated soil.

The S. capricornutum EC₅₀ for the stabilized dry well soil eluate was 3.0 percent. At this dilution the calculated total chromium concentration was 0.6 mg/L. There was a dramatic decrease in the total chromium eluted after the dry well soil had been stabilized, and toxicity endpoints (EC₅₀ and LC₅₀ for S. capricornutum and D. magna, respectively) suggest some toxicity reduction. While stabilization reduced the toxicity of the dry well soil eluate, the process appeared to have added toxic constituents to the soil that were not present prior to stabilization. Despite the large decrease in toxicity after stabilization, EC₅₀ and LC₅₀ effects occurred at concentrations ≤ 20 percent eluate. Every acute and short-term chronic toxicity test performed on the stabilized dry well soil, or eluates prepared from it, provided EC₅₀ or LC₅₀ results at concentrations ≤ 20 percent.

Toxi-Chromotest assays on deionized water eluates prepared from the dry well soil were also highly toxic (Table 2; EC₅₀s in the duplicate tests were 1.6 and 3.5). Toxi-Chromotest detected a 7-fold decrease in toxicity after soil stabilization, and the moderately toxic EC₅₀ of 24.9 percent eluate was the lowest EC₅₀ reported for any bioassay performed as a part of this study. Microtox^R bioassays performed on deionized water eluates yielded EC₅₀ concentrations ≤ 6.8 percent eluate (Table 2).

Stabilized soil quantities were insufficient for assessing toxicity to earthworms, but the reference soil that was tested appeared nontoxic to earthworms. The non-stabilized dry well soil, however, elicited a highly toxic response when tested with earthworms and reinforced the information provided by the other bioassays in the toxicity test battery (Table 2).

The reference soil was not toxic to the lettuce seed, but the stabilized reference soil was highly toxic. Stabilization of the dry well soil clearly did not decrease toxicity as measured by the lettuce seed germination test. Testing non-stabilized dry well soil

eluates with the lettuce seed test yielded LC_{50} s that supported results from the algal assay performed on eluates of this same parent material (Table 2).

Sodium acetate eluates were prepared from the reference soil because the TCLP is used by the EPA to chemically assess metals extracted from hazardous waste site soils; EPA Region 10 staff were also performing TCLP extractions on subsamples of these soils. Toxicity bioassays performed on TCLP eluates ranged from high to moderate toxicity (Table 2). Results from non-stabilized reference soil, however, suggested that the non-stabilized reference sample did not contain toxic constituents. The toxicity apparent in these bioassays was undoubtedly caused by the sodium acetate eluant. Peterson et al. (1987) reported sodium acetate EC_{50} or LC_{50} values (v:v% [95% confidence intervals]) for S. capricornutum, D. magna, and the lettuce seed (Lactuca sativa) root elongation test (1.2% [0.9-1.7]; 45.8 [43.7-48.0]; and 15.0 [6.4-26.8]), respectively), and the sodium acetate eluate for the reference soil fell within those reported ranges. Sodium acetate eluates are not suitable for toxicity testing with S. capricornutum, D. magna, and L. sativa.

CONCLUSIONS

1. Both the chemical analysis and toxicity bioassay results indicated the reference soil did not contain toxic constituents.
2. Unknown constituents of the stabilization process, when added to the reference soil, elicited toxic responses in the plant bioassays.
3. For the TCLP eluates from the reference soil, the toxicity results from S. capricornutum, D. magna, and the lettuce seed (L. sativa) root elongation bioassays suggested that sodium acetate (approximately 20 g/l) is toxic in itself and is not appropriate for bioassessments with these test systems.
4. Chromium was present in high concentrations in the dry well soil eluates from stabilized and non-stabilized samples and was probably the most toxic constituent in the eluates.
5. All acute and chronic toxicity bioassays performed on the non-stabilized and stabilized dry well soils, and deionized water eluates prepared from the soils, reported high toxicity (EC_{50} or LC_{50} 's ≤ 20 percent site sample); although the Toxichromotest did report a reduction in toxicity in the stabilized treatment.

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